Romana HANŽLOVÁ[1], Zuzana HUDOVÁ[2], Jiří MÁLEK[3], Oldřich NOVOTNÝ[4], Jana PAZDÍRKOVÁ[5], Jan ZEDNÍK[6]

RECENT EARTHQUAKES IN THE ORLIK RESERVOIR REGION
NEDÁVNÁ ZEMĚTŘESENÍ V OBLASTI PŘEHRADY ORLÍK

Abstract

V sobotu 13.1.2007 v 8:30 UTC zaregistrovaly seismické stanice v České republice i jejím blízkém okolí zemětřesení s epicentrem v blízkosti přehrady Orlík. Lokální magnitudo jevu je 2,4. Otřes byl pocítěn také obyvateli v několika obcích v okolí přehrady s maximální intenzitou 5° EMS-98. Nejbližší seismické stanice zaregistrovaly od roku 1992 více než 20 mikrozemětřesení z této oblasti, jedno z nich s magnitudem 1,1 bylo také makroseismicky zaznamenáno. Z historických katalogů není seismická aktivita v tomto regionu známa.

Key words: shallow earthquake, Orlík reservoir

Introduction

On Saturday 13.1.2007 at 8:30 UTC inhabitants in several villages near the Orlík reservoir heard a loud bang. What they were first presuming an explosion from a nearby quarry in the village of Lašovice proved to be an earthquake. It was recorded by almost all Czech seismological stations and also by numerous stations abroad (Austria, Germany, Poland, and Slovakia) up to the distance of about 280 km (Fig. 1).

Seismic records

The nearest seismological stations are those of the Háje local seismic network operated by the Institute of Rock Structure and Mechanics, Prague (IRSM) monitoring the underground gas storage Háje near Příbram. Seven stations of this network lie in distance ranging from 13 to 17 km NW of the epicentre. Five stations of the Temelín local seismic network (Nehybka et al. 2006) operated by the Institute of Physics of the Earth of Masaryk University, Brno (IPE) are situated 33 to 65 km S to SSE from the epicentre. The nearest stations of the Czech Regional Seismic Network are the Průhonice station (PRU) 54 km NNE and the Kašperské Hory station (KHC) 64 km SW from the epicentre.

Data from all available stations were collected at the IPE Brno and analysed (Fig. 2). The earthquake was localised by the LocSAT programme using the IASPEI travel-time curves with readings of longitudinal and shear waves from all the stations. Altogether 63 arrival times from 38 stations in distances ranging from 13 to 280 km were used. The coordinates of epicentre, obtained in this way, are 49.55°N and 14.19°E. The depth of hypocentre according to this localisation is 2 km, which corresponds well to the relatively strong macroseismic intensity of the earthquake. Nevertheless, the accuracy of this localisation is restricted due to the global seismic velocity model used. The error of epicentre determination might be estimated up to the first kilometres. The most questionable parameter is the depth (its reliable determination requires a station in close vicinity to the epicentre). Considering the computed localisation and other features of the seismograms (e.g. surface waves visible also at the closest stations) it can be presumed that it was a shallow earthquake with a depth not exceeding 10 km.

[1] RNDr.**,** Institute of Physics of the Earth, Masaryk University, Tvrdého 12,Brno, romana.hanzlova@ipe.muni.cz
[2] Mgr., Geophysical Institute AS CR, v.v.i. Prague , Boční II/1401, Prague, hudova@ig.cas.cz
[3] RNDr., Ph.D., Institute of Rock Structure and Mechanics AS CR, v.v.i, Prague, V Holešovičkách 41, Praha 8, malek@irsm.cas.cz
[4] Doc. RNDr., CSc.Department of Geophysics, Faculty of Mathematics and Physics, Charles University, Prague, V Holešovičkách 2, Praha 8, on@karel.troja.mff.cuni.cz
[5] RNDr.**,** Institute of Physics of the Earth, Masaryk University, Tvrdého 12, Brno, jana.pazdirkova@ipe.muni.cz
[6] RNDr., Geophysical Institute AS CR, v.v.i. Prague , Boční II/1401, Prague, jzd@ig.cas.cz

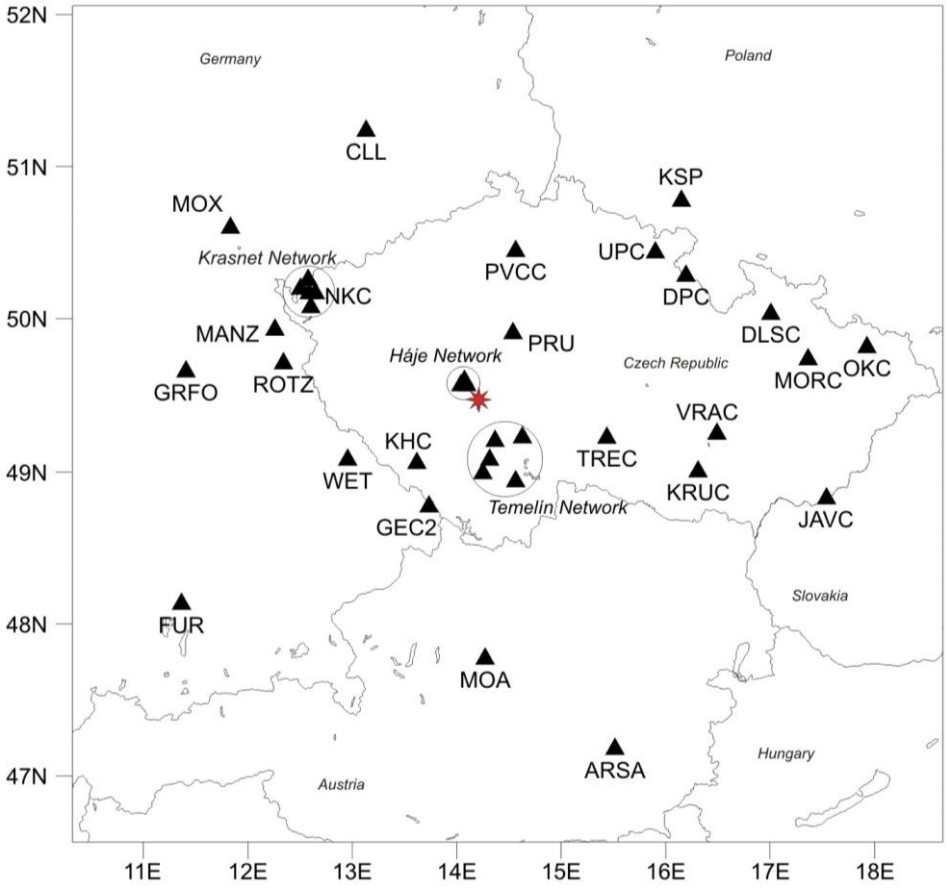


Fig.1 Stations recording the Orlík earthquake of 13.1.2007.

Amplitudes of shear waves were evaluated on vertical components of eleven stations operated by the IPE and used for the determination of the local magnitude (Scherbaum and Stoll, 1983). The magnitude ranges from 2.1 to 2.7, the average value is 2.4.

The earthquake was also localised by the Seismic Department of the Geophysical Institute of the Academy of Sciences, Prague (GI). This localisation did not include readings from the local networks Háje and Temelín situated close to the epicentre. The computation by the LocSAT programme utilized 18 readings from 10 stations. The resulting epicentre coordinates are 49.57° N and 14.18° E, the depth of hypocentre was determined to zero. Compared with the location using the data from the local networks there is a 2 km shift of the epicentre to the NNW, which can be considered as a good agreement. The magnitude was determined by the use of amplitudes of shear waves on vertical components (Zedník et al. 2001). The local magnitudes at the respective GI stations range from 1.4 to 2.3.

There is a good chance to improve the location in the future using the blasts at the Lašovice quarry, which is situated approximately 3 km east of the determined epicentre. Exact coordinates and times of two explosions carried out in this quarry later in January 2007 were measured and their seismograms recorded at the local networks Háje and Temelín will be correlated with those of the earthquake using the master event method.

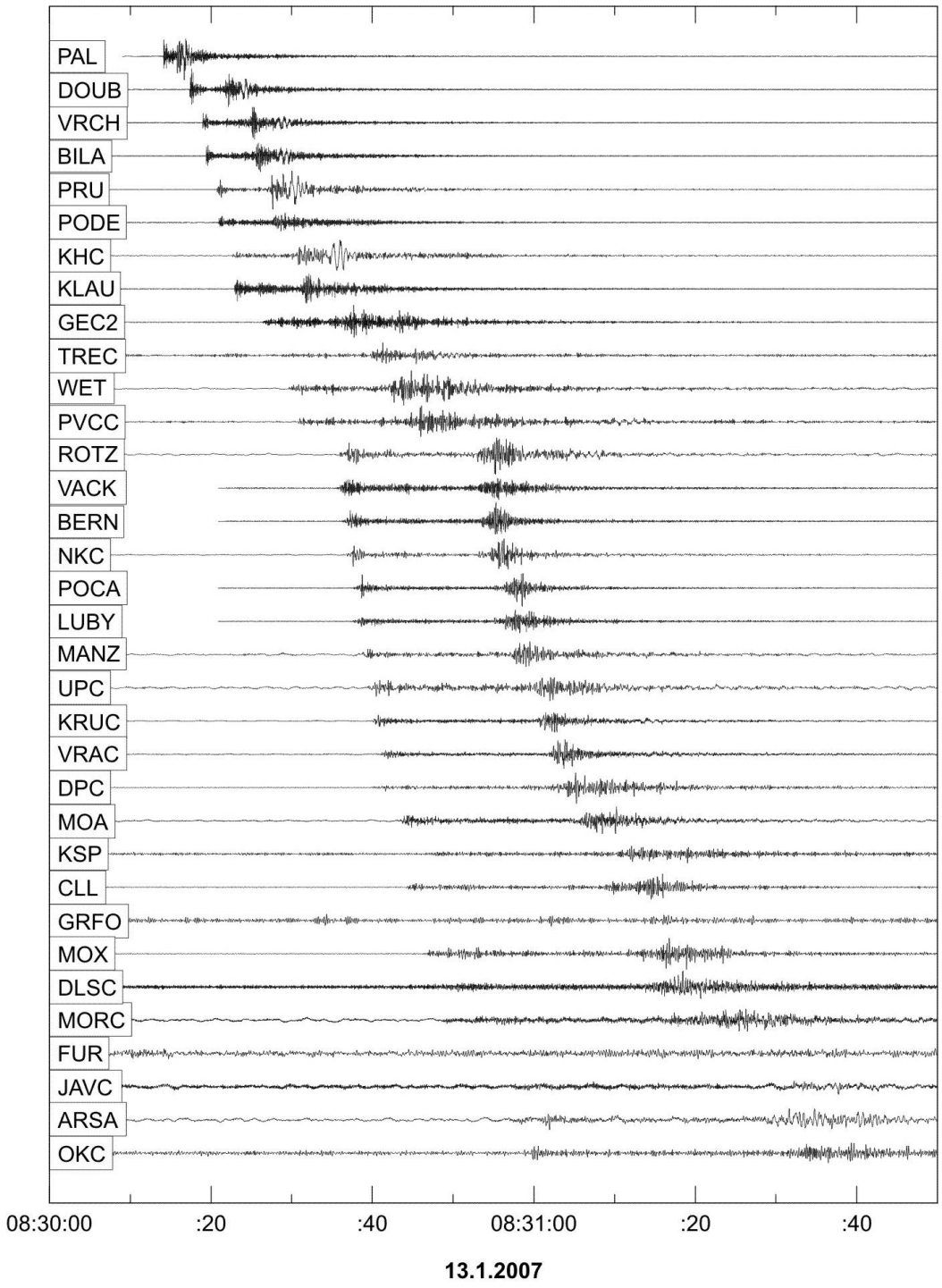


Fig.2 Seismograms of the Orlík earthquake of 13.1.2007, vertical components, the closest Háje network is represented only by the PAL station.

Macroseismic observations

The earthquake of 13.1.2007 was observed by inhabitants of several villages around the Orlík reservoir. The event was described in detail in the local paper: *Some people witnessed the impression of their house being lifted and sit down again. A loud bang was heard in the villages of Chrást, Klučenice, Voltýřov or Koubalova Lhota. People were presuming it was an explosion at the Lašovice quarry or an explosion of someone's boiler. At Voltýřov people were running out to the square* (Milevské noviny 4/2007 of 24.1.2007).

Three macroseismic questionnaires were gained and two more observation sites are known from hearsay evidence. Observation sites, both from macroseismic questionnaires and from the local newspaper, lie on both sides of the Vltava River, in the area between the Orlík castle and the dam. The farthest place of observation is approximately 8 km of the epicentre (Fig. 3).

Despite the relatively low magnitude this event reached a striking intensity. Slight damage on buildings was found such as hairline cracks and fall of small pieces of plaster. People heard rumble, felt strong trembling of buildings and heavy furniture, and observed shifting of light furniture, swinging of hanging objects and rattling of doors and windows. The maximum ascertained intensity corresponds to grade 5 of the EMS-98 macroseismic scale.

Recent and historical earthquakes in the region

The above mentioned earthquake of 13.1.2007 is not the only one known from this region. The Háje and Temelín local networks recorded altogether 26 microearthquakes with epicentres near the Orlík reservoir in the last 15 years (Fig. 4). A prevailing number of them were of magnitude smaller than 1. In addition to the event of 13.1.2007 there had been one more macroseismically observed earthquake of 2.10.2000 at 18:37 UTC with a local magnitude of 1.1 which was felt in the villages of Klučenice, Milešov and Voltýřov with the maximum intensity of 4^o on the EMS-98 macroseismic scale.

Another interesting phenomenon is also a mini-series of 17.-18.9.2006, when the Háje and Temelín local networks recorded 9 earthquakes from this area within 10 hours. The first and the last event of this series had magnitudes of 1.5 a 1.1, respectively, and their waveforms look different. Also the earthquake of 13.1.2007 is different from both the September 2006 events. This feature is documented by seismograms from the nearest PAL station of the Háje network, 13 km from the epicentre, where there are visible differences in the global appearance of the records and also in the orientation and amplitude of the first onsets (Fig. 5). The other events from the series were much weaker, with magnitudes around 0.

While in the last seven years there were two macroseismically observed earthquakes from the Orlík region, there is no record corresponding to this region in the historical catalogue of Czech earthquakes (Kárník et al. 1957, Kárník et al. 1981). Therefore it cannot be excluded that this seismic activity has been induced by the operation of the Orlík hydroengineering structure. The dam was built in 1956-1966 and after filling the reservoir the water level rose by 75 m. With its height it ranks as the highest one in the Czech Republic. The question remains why there was no seismic activity observed much earlier after filling the reservoir. Some delay between the filling and the occurrence of induced seismicity was observed worldwide (Gupta, 2002), but several tens of years of duration of the delay is rather exceptional. The explanation could be that the local seismological networks became operational as late as in the 1990s (Temelín in 1991 and Háje in 1998) and before that the seismic activity around the reservoir might not have been recognised. Even during the operation of the local networks their sensitivity varied. Nevertheless the fact is that the earthquake of 13.1.2007 has been the strongest earthquake from this region during the operation of the Temelín monitoring network.

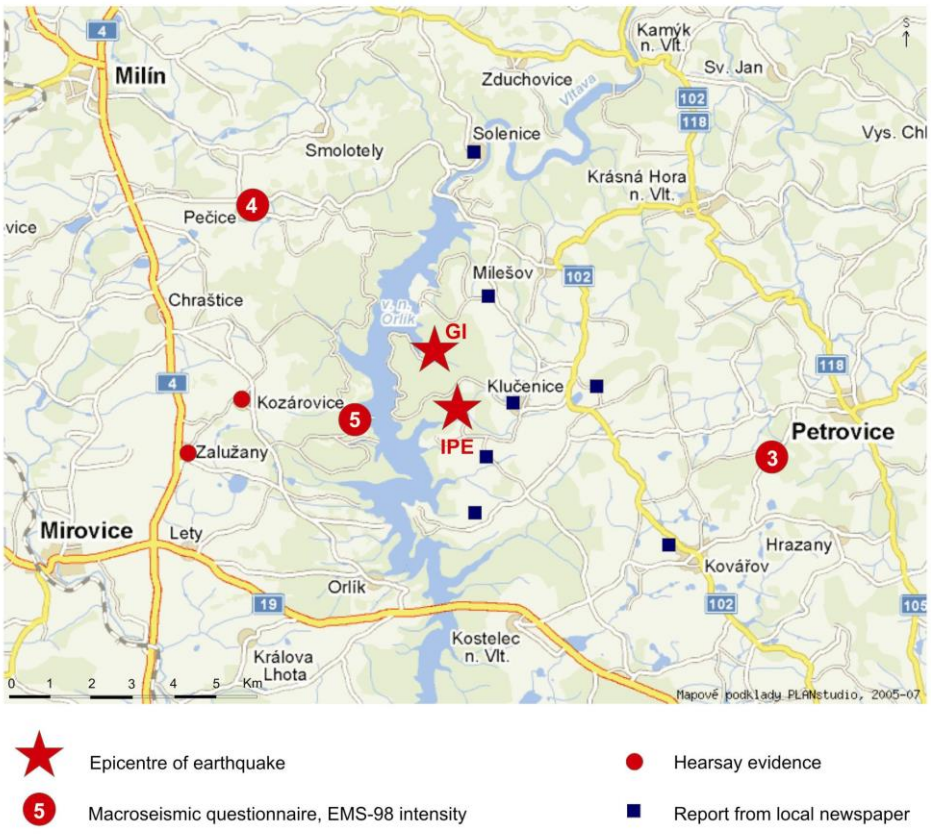


Fig.3 Map of macroseismic observations of the Orlík earthquake of 13.1.2007.

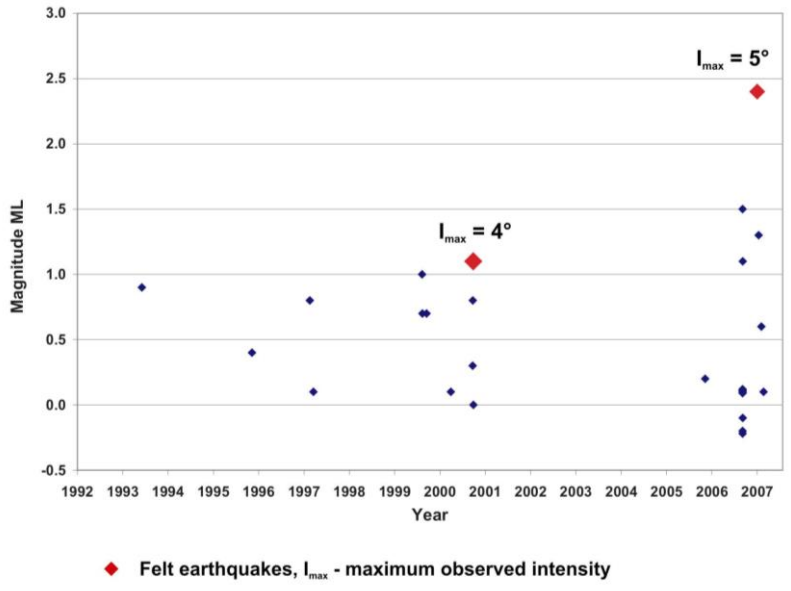
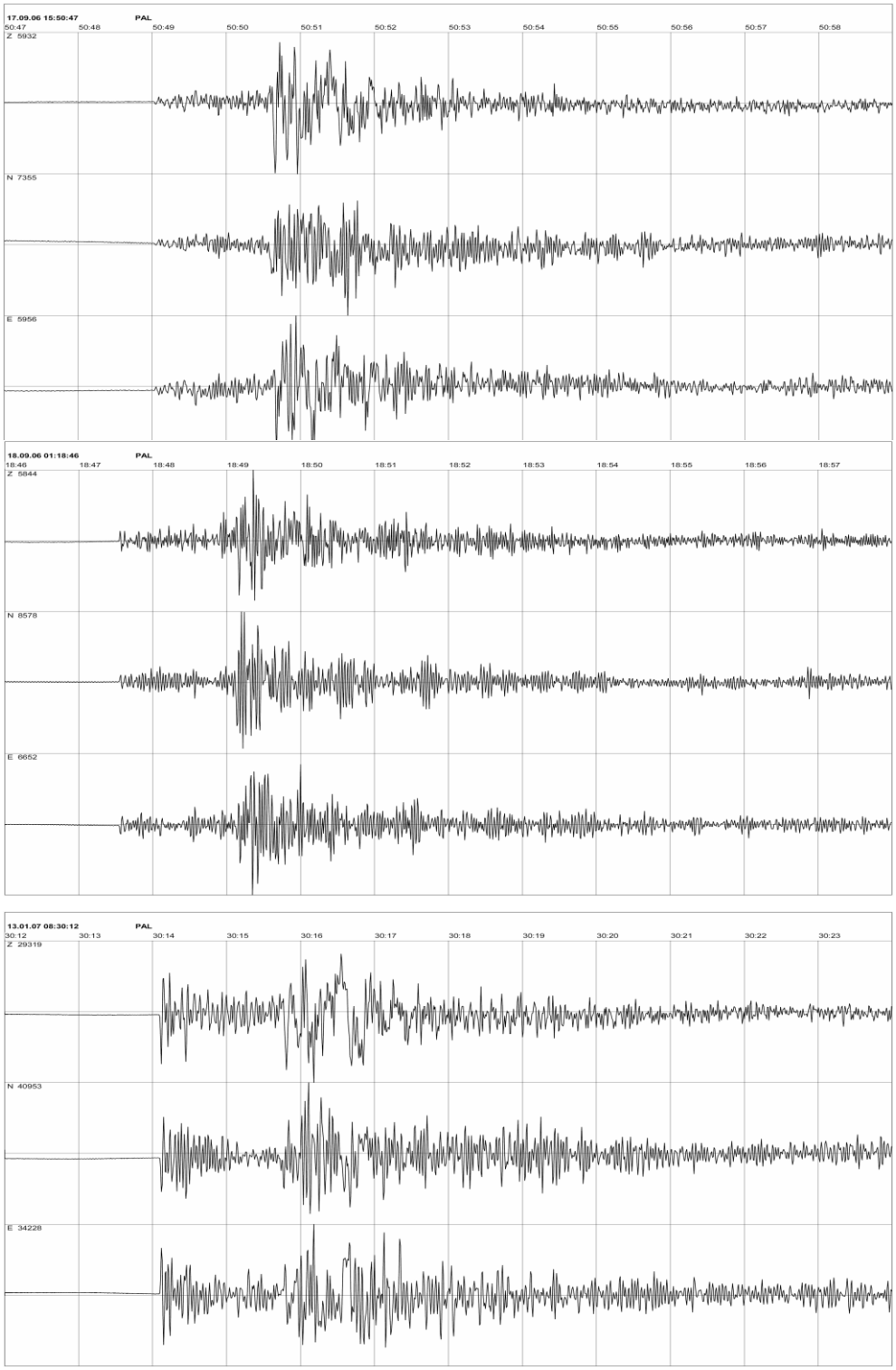


Fig.4 Microearthquakes from the Orlík region recorded since 1992.

Fig.5



Comparison of three earthquakes from the Orlík region recorded at the nearest PAL station of the Háje network: 17.9.2006 - magnitude 1.5 (top), 18.9.2006 - magnitude 1.1 (middle), 13.1.2007 - magnitude 2.4 (bottom).

Conclusions

The Orlík earthquake of 13.1.2007 belongs to the most significant recent events with epicentres in the Czech Republic. It was recorded in high quality by a great number of seismic stations and despite its relatively low magnitude it was macroseismically observed with a striking maximum intensity 5^{o} of EMS-98 macroseismic scale. It is the second macroseismically observed earthquake from the region with more than 20 weak microtremors recorded by nearby stations during the last 15 years. No records from this region can be found in historical catalogues of earthquakes and therefore the possibility of the seismicity being induced by the Orlík water reservoir cannot be excluded.

Acknowledgement
This work was partially supported by the research projects in the Czech Republic: A300460602, OZ30860518 of the Academy of Sciences CR, and by MSM 0021620800. The authors would like to thank the Temelín NPP and RWE Gas Storage, s.r.o. for the permission to use their data.

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